CELRE-EC-GSB 28 September 2020

MEMORANDUM FOR CELRE-EOS, File

SUBJECT: Soo Locks Complex, West Center Pier (WCP) 5 July 2020 Atlantic Huron Vessel Strike Trip Report

1. A site visit was conducted on 14 July 2020 to investigate damages related to the vessel strike by the Atlantic Huron, which occurred on 5 July. A visual inspection of the damaged area was performed, as well as video inspection through dive inspectors of the below water structure. Dive operations were performed by the SAO dive team. A marine surveyor from Hayes Stuart, Inc. named Capt. Francis D'Souza was present during the time of inspection. Observations, findings, and recommendations with applicable photos are included in the report below. Additional supporting drawings and reference information has been provided in Appendix A.

2. Observations & Findings.

a. Visual Observations Above Water: The impact location occurred at the southwest corner of the first timber crib east of the steel sheet pile (SSP) cells constructed during the 1964 west center pier (WCP) extension (Figure 1). For structure identification and naming convention, see Figure 2. This crib is identified as crib #6 from the 1906 WCP crib drawings. The timber fender was crushed and split at the location of initial impact (Figure 3). Fraying and rub marks were present past the initial impact location where the vessel rubbed along the fender (Figure 4). At the location of impact, the concrete cap of the existing timber crib was shifted north approximately 5 ¾" and rotated clockwise (Figures 3 to 5). This caused the SW corner of the cap to be crushed into the SSP Cell (U-20) cap (Figure 6). Three large spalls were visible: two in the adjacent U-20 cell cap along the perimeter of the 1994 concrete cap repair area (Figures 8 to 12), and one along the rounded edge of the crib #6 cap There was visible mounding of the soil in the center grassy area of the WCP directly north of the concrete pavement (Figure 7). The mounding soil could be felt and visually observed from directly behind point of impact extending East approximately 50ft behind the existing crib wall. Flexible joint sealant material was visibly displaced from joints (compressed, torn, stretched, etc.) showing relative movement between concrete caps, pavement, and mooring bollard foundation (Figures 13). The mooring bollard foundation ranged between 5/8" and ¾" higher on the south edge relative to the north edge based on land survey data (Figures 14 & 15). An increase of ¾" in the expansion joint width north of the bollard was measured. The vertical displacement may be due to rotation of the foundation from lateral loading applied by the pavement and/or the concrete strut below the pavement (See Appx A. Figures A-1, A-2). The condition of the mooring bollard struts is unknown due to their inaccessibility.

Figure 1 – Aerial View – Location of Impact along West Center Pier

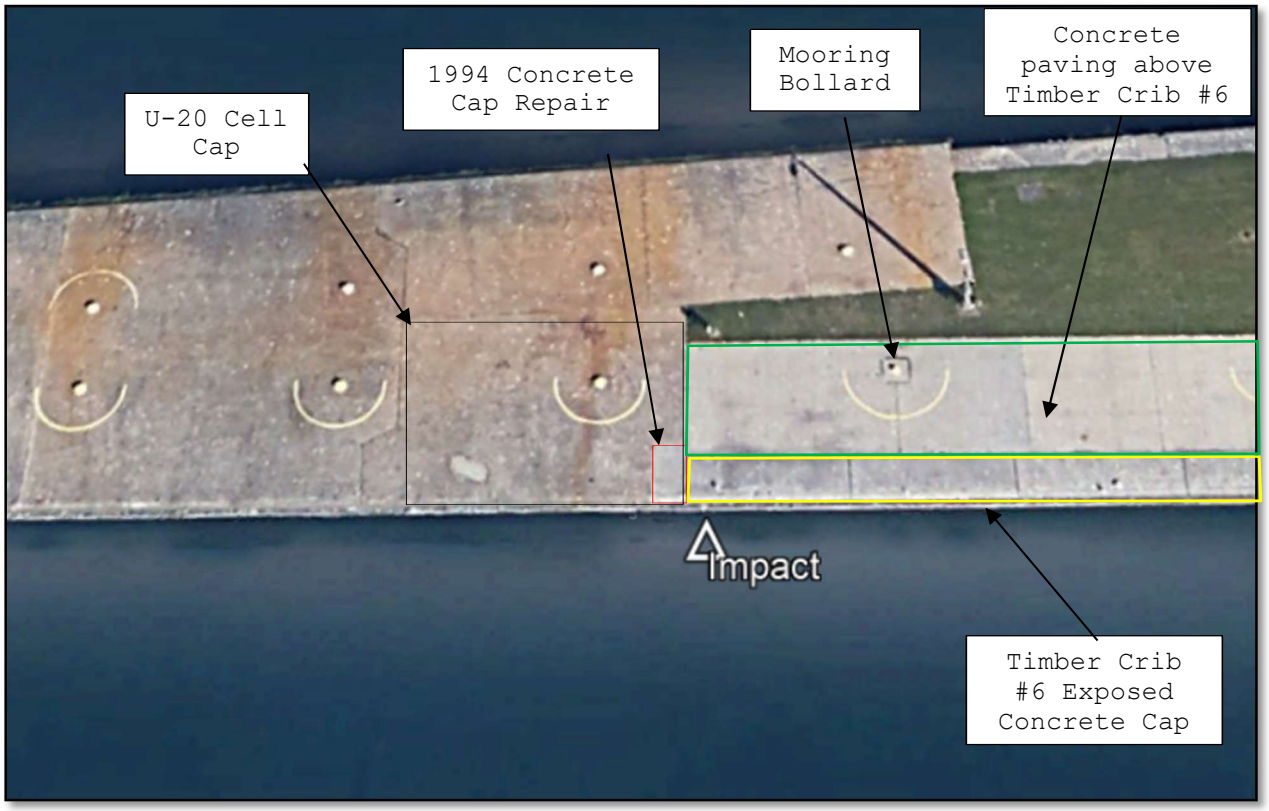


Figure 2 – Structure Identification

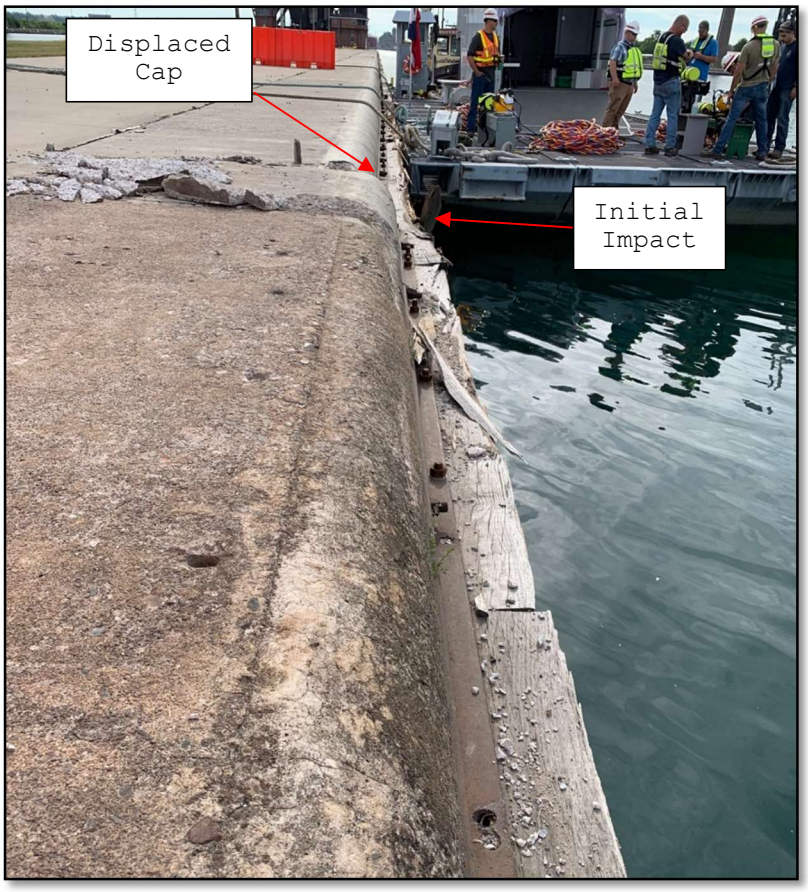


Figure 3 - View looking downstream (East) along WCP. Location of impact evident by crushed timber fender and displacement of timber crib wall concrete cap

Figure 4 – View looking upstream (West) along WCP. Displacement of cap and connecting fender assembly clearly visible

Figure 5 – Displacement of approximately 5 ¾” of timber crib #6 cap northward relative to cell U-20 cap south face.

Figure 6 – Adjacent U-20 cell cap crushed and split. Spalling visible on surface and edges. Displacement of timber crib cap visible, damaged finders and fender brackets.

Figure 7 – Soil displaced behind concrete pavement north of crib wall cap (denoted by pink paint). Separation of NW corner of pavement from U-20 cap showing rigid body rotation of pavement

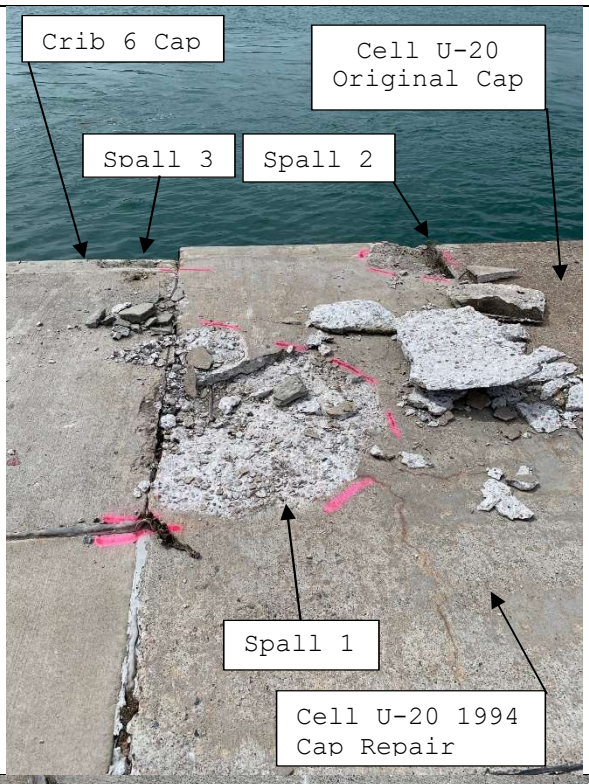
Figure 8 - Concrete Spalls	
Figure 9 - Spall 1, 45” x 34” x 2.5” Deep. Approximately 9” of rebar exposed. East edge of U-20 cell cap repair area	

Figure 10 - Spall 1, Exposed rebar and concrete debris visible	
Figure 11 - Spall 2, 18” x 23” x 3” Deep. No visible rebar. West edge of U-20 cell cap repair area	

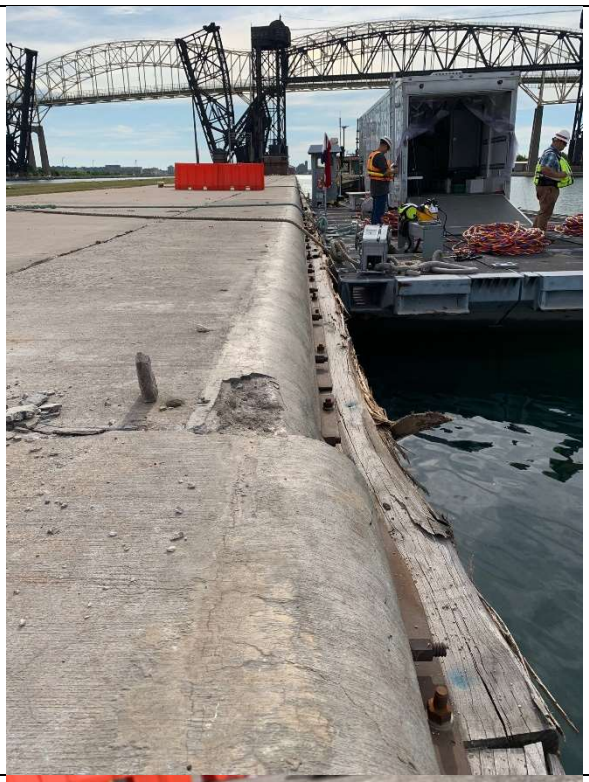
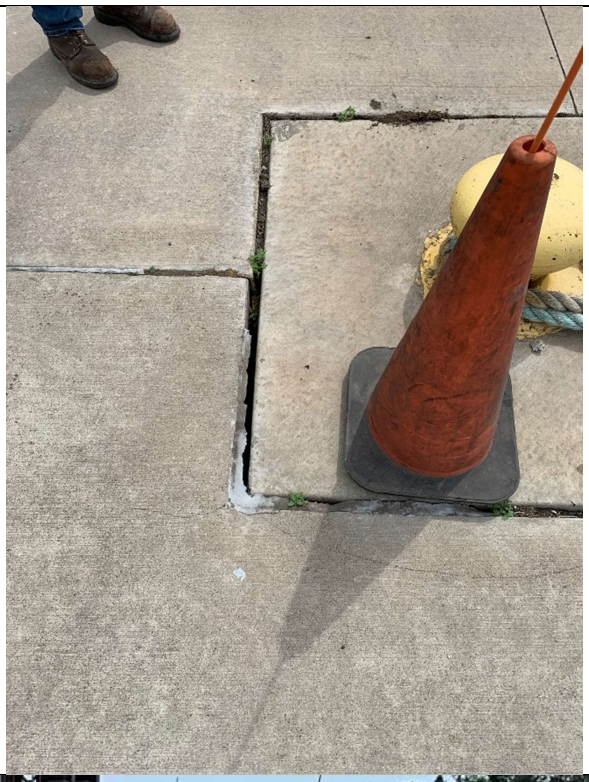
Figure 12 – Spall 3 8” x 12” x 1.5” deep. Rebar exposed along south face at corner; none on top surface		
Figure 13 - Joint Material compressed out of joint between timber crib #6 and U-20 cell caps		

Figure 14 – Displacement of pavement relative to mooring bollard foundation (left is north) of roughly ¾”.	
Figure 15 – Rotation of bollard foundation causing south edge elevation to range between 5/8” and ¾” above north edge	

b. Visual observations below water. Two divers performed dive operations during the site visit. Both divers had cameras on their dive helmets that allowed for remote observation from the dive trailer, which was mounted on a barge and moored along the WCP just upstream from the vessel impact location. Divers visually and tactilely inspected the wall from the channel rock bottom up to the water line.

c. There were no visible signs of direct impact by the vessel hull below the water line (Figure 16) (i.e. deformations in steel plating or scuffs in algae on wall). The

divers were able to take relative measurements from a plumb-bob (hanging on south side of timber fender), which ranged from 24” at the bottom most exposed horizontal timber member (above 1994 rock ledge repair work) to 31” at the top most timber member, a difference of 7” over the exposed crib height. A portion of the 1 ¼” difference between this and the measurement of the cap displacement of 5 ¾” may be due to the accuracy of the underwater measurements and the location of measurements on irregular timber crib surfaces. The measurements verify that the crib members below the concrete cap displaced laterally with the concrete cap. Thus the timber crib has a permanent tilt northward (Figure 19).

d. The top horizontal timber appeared to be rolled northward to a greater degree than the crib members below it. This was evident by the large rotation visible and gap present between it and the next crib below it (Figure 18). This may account, at least in part, for the 1 ¼” measured difference mentioned in the previous paragraph. In addition, there was a large gap between the top timber and the bottom of the concrete cap with an exposed steel rod connecting the two. The steel rod had a slight but visible bend northward (Figure 17).

e. The divers probed into the horizontal crib joints with folding rulers. Probed depths varied from 20” to greater than 70” (Figure 20) due to limited reach with the measuring tools. This indicates that the rock fill material is missing for portions of the upper half of crib (top 7 horizontal timbers).

Figure 16 – Existing steel channels and heavy lag bolt along west edge of crib #6 (1994 repair) appear to be unchanged.

Figure 17 – View East from between crib and cell U-20 bulb at bottom of cap. Approximately 4” to 6” of separation between cap and top crib member. Rolling of top crib member visible.

Figure 18 – Relative rotation of top crib face member (right) and tie-back member (left) visible by gap at square cut end

Figure 19 – Visible Tilt of timber crib wall (7/5/20 from ROV)

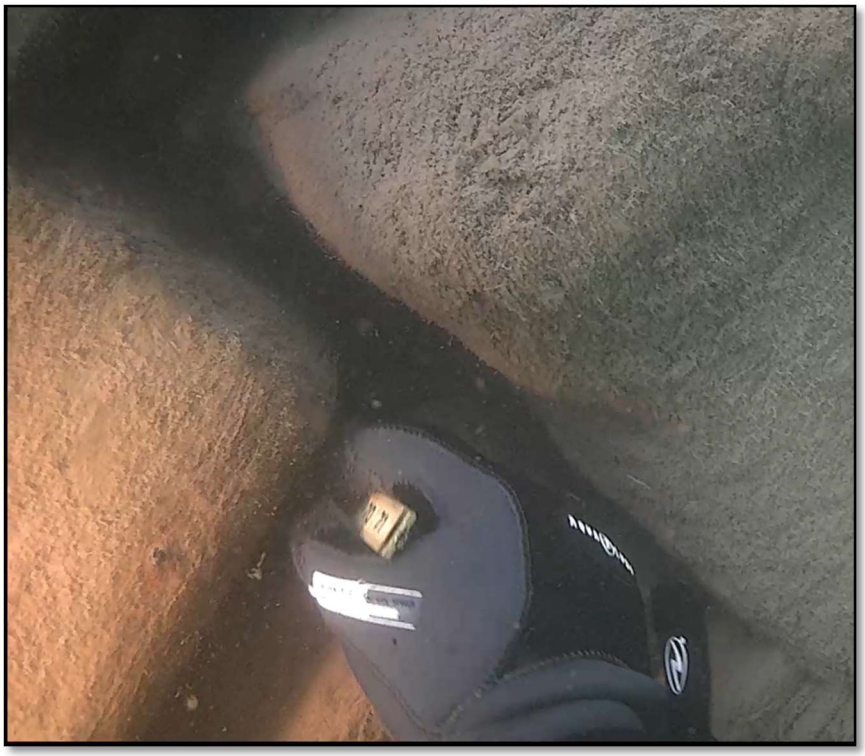


Figure 20 – Diver probing at first mortise & tenon joint from top. Probe depth greater than 70 inches.

3. Recommendation/Conceptual Plan for Repair.

a. Correction of missing timber crib fill material: The crib structure requires additional fill inside to provide the mass necessary for stability of the structure. The missing fill material is likely due to settlement of original fill material, which was generally ungraded spoil stone from channel excavations, or undermining of the rock ledge, which has since been repaired (Figures A-4 through A-8). For ease of placement, a pumped underwater concrete material is recommended. Holes can be drilled through the cap to provide access into the crib structure around the perimeter, or a flexible pipe may be placed between the cap and top crib where a gap currently exists. Material would need to be placed around the perimeter of the crib and proceed upwards. Estimates of fill are shown in Figure 21 and are based on diver probing at the westernmost end of crib #6.

b. Correction of damaged timber fenders: The timber fenders show signs of splitting and fraying from impact. New timbers shall be installed to replace damaged timbers a minimum of 50 linear feet.

c. Correction of mis-alignment: The timber fender and cap have moved sufficiently that the rubbing surface is no longer straight along the wall face. The existing steel angles and timber fenders will need to be removed and an extension of the concrete cap created to bring the face back into alignment. Upon installation of the new concrete cap extension, new angle iron, fenders, and fender bolts can be installed. See Figure 21 for a conceptual repair.

d. Correction of damaged concrete cap. The existing concrete cap and pavement sections were pushed north and rotated clockwise upon impact of the crib cap southwest corner. This led to the crushing and spalling of adjacent concrete surfaces. Concrete spall areas will require repair (Figures 8 through 12). Typical spall repair shall be followed with 2” deep saw-cut perimeter lines, chipping out of damaged concrete to a minimum of 1” below existing rebar. Rebar and concrete shall then be cleaned prior to new concrete placement. Concrete shall have a minimum compressive strength of 4500 psi.

(1) The 1994 repair area of the SSP cell cap has a 1/8” wide crack along the full length and approximately 6 inches deep. The concrete shall be cut and/or chipped out to sound concrete along the full perimeter of repair area and replaced. Chipping shall extend a minimum of 1 inch below existing rebar to provide adequate bond.

(2) As an alternative to chipping around rebar, concrete and rebar may be saw cut and removed. However, new rebar must be installed by drilling and epoxying into existing concrete to match the size, quantity, and approximate spacing of existing bars.

e. Correction of damaged concrete joint material: Where the concrete cap has moved, the existing joint material has either been detached, torn, or compressed beyond serviceable limits. Therefore, all joint material for the rotated crib shall be removed and new joint sealant installed (50 linear feet of wall). Sealant shall be either one or two part polyurethane with an appropriate sized backer rod in accordance with manufacturer's instructions.

f. Correction of bollard foundation movement: If the existing struts are in tact without damage, there does not appear to be a need for correcting the bollard alignment for operational or structural purposes.

g. Correction of soil mounding: Soil in the backfill of crib 6 has physically moved (mounded) where pushed by the concrete crib cap and slab. The soil shall be tilled, graded, and seeded.

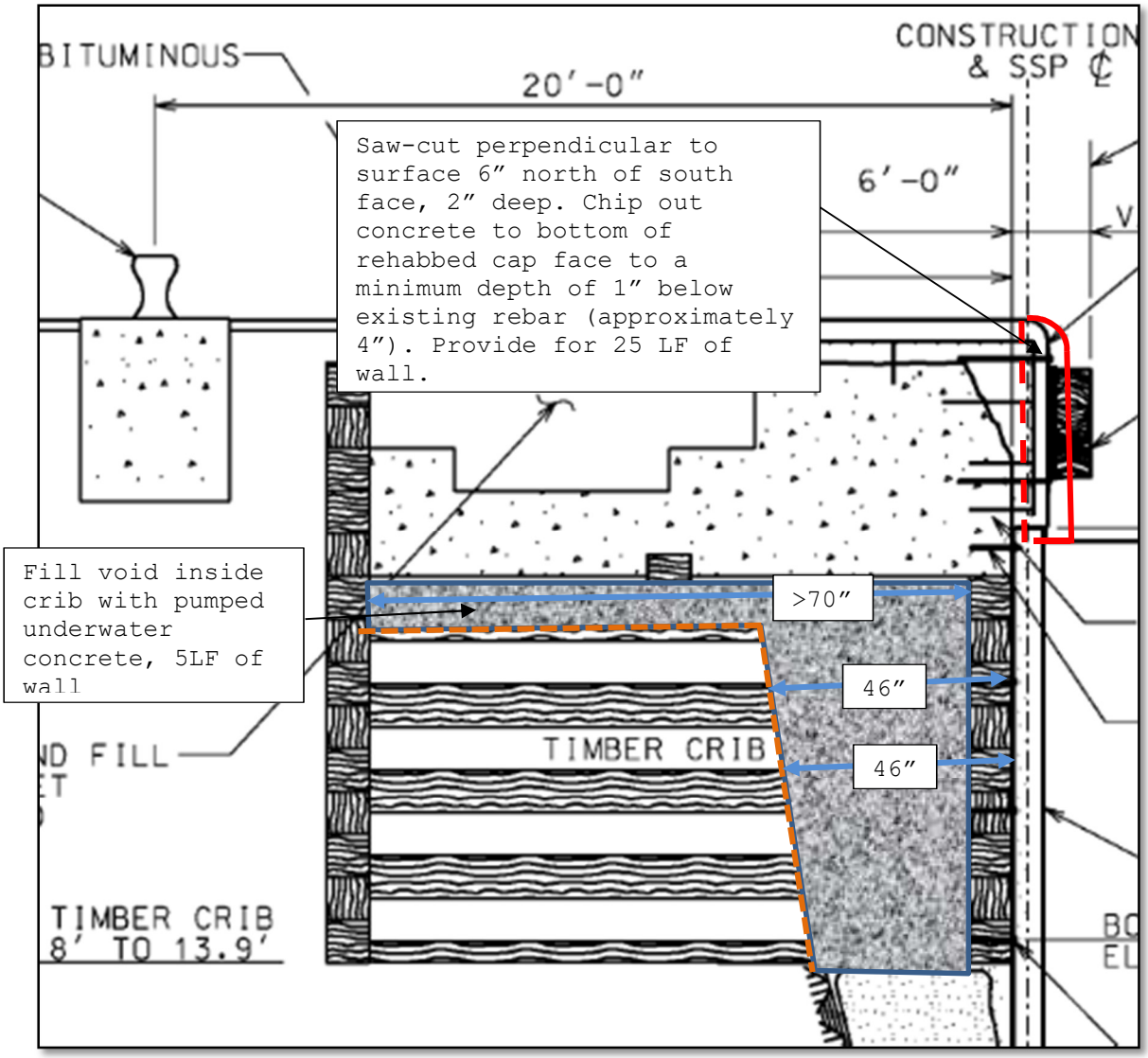


Figure 21 – Repair: Void filling and cap realignment

4. Further investigation. Due to the inability to view the existing bollard concrete strut below the concrete pavement surface, further investigation is recommended to assess the strut for damage. A 2’ wide trench in the concrete pavement shall be cut-out, starting from the bollard foundation to 3’ past the strut mid-point. See Figures A-1 and A-2 for applicable reference drawings. After investigation, the trenches shall be repaired in kind.

4. Rough Order of Magnitude Cost Estimate. A rough order of magnitude (ROM) cost estimate has been prepared by the Cost & General Engineering Branch and will be provided as a separate document.

Encl
Appendix A

CLINT E. DOUGHERTY, S.E., P.E.
Structural Engineer, SME
CELRE-EC-GSB

Appendix A

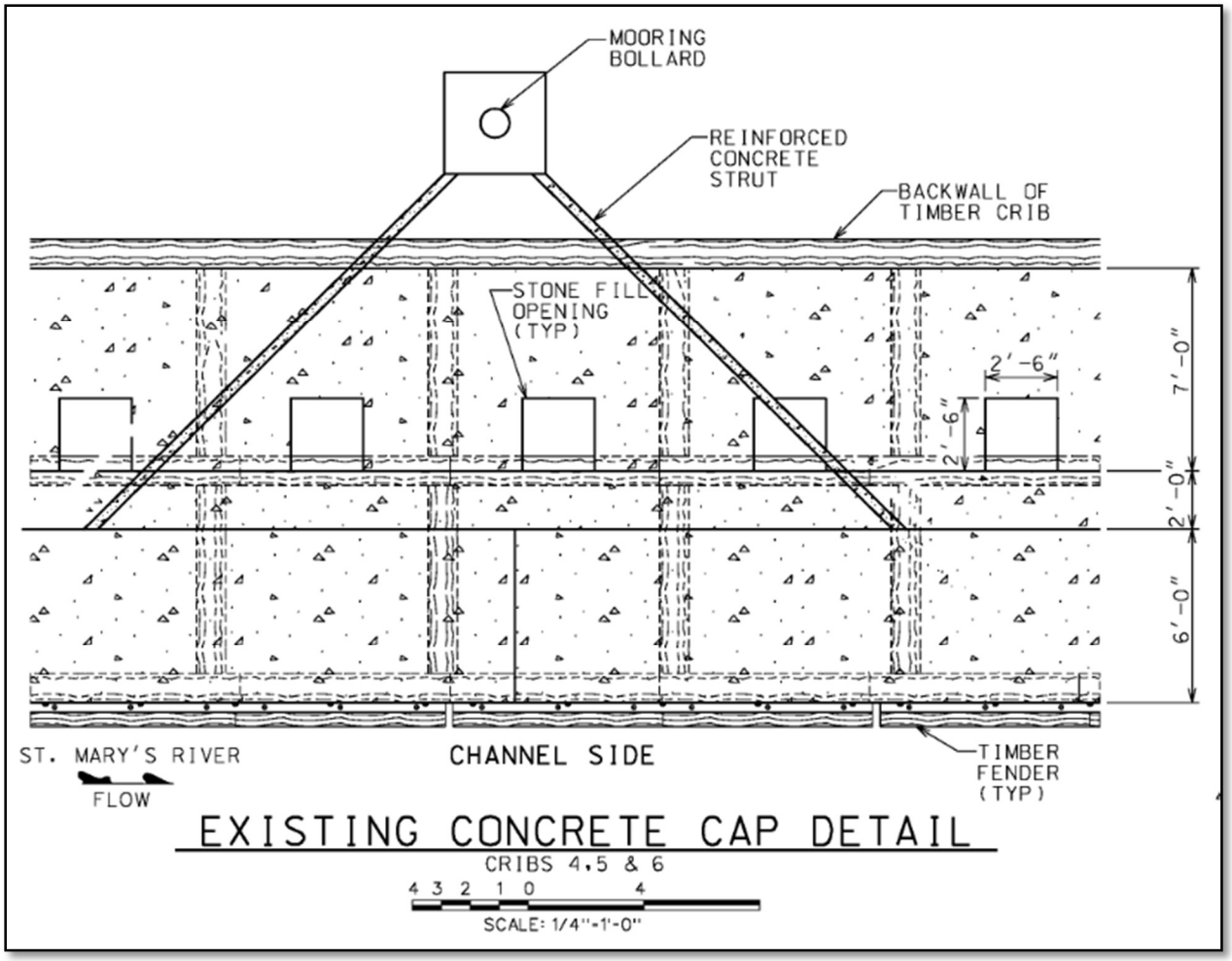


Figure A-1: 2002 WCP S. Wall Rehab (plans showing assumed existing detail of crib 6 with concrete struts at bollards.)

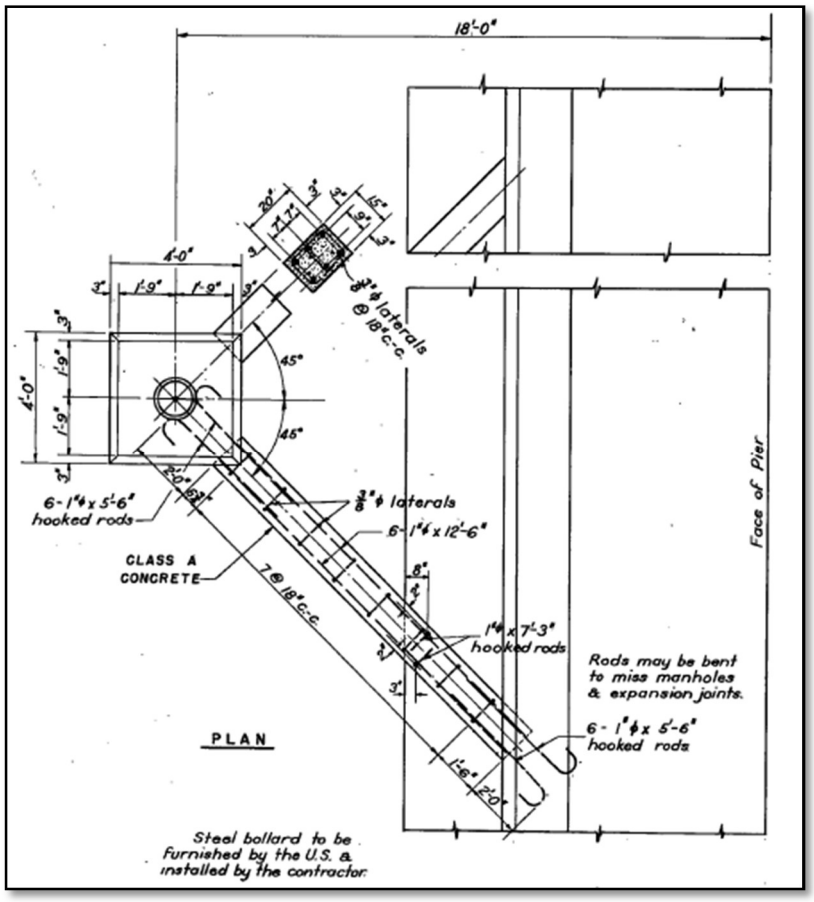


Figure A-2: Assumed dimensions of bollard struts (from SW Pier drawing DC-30-29 dated 1944)

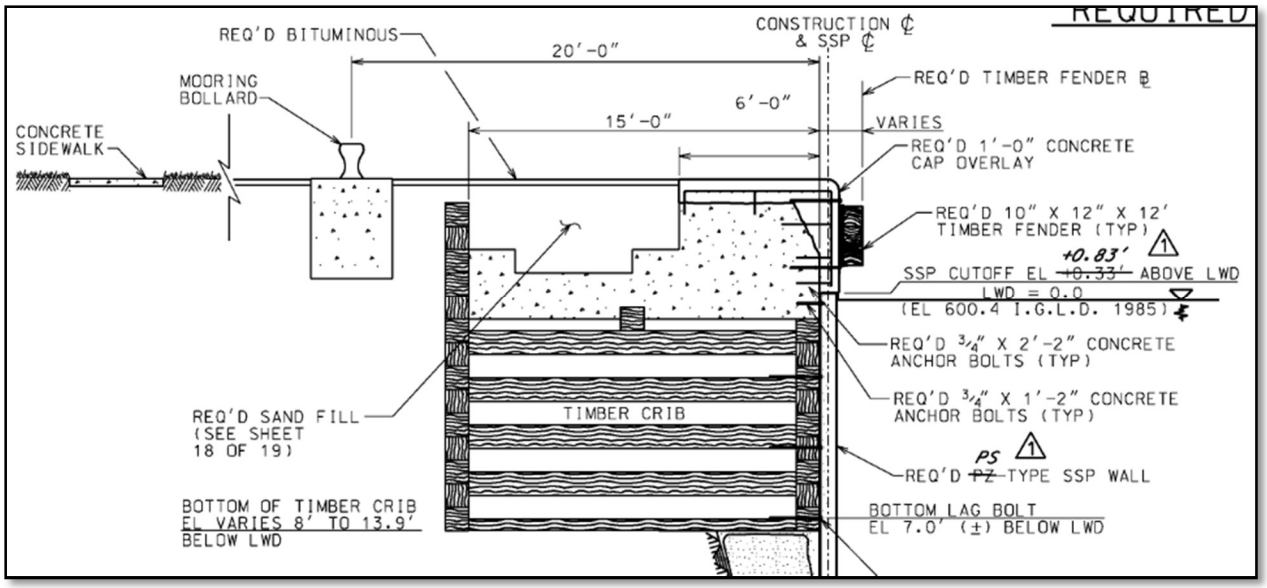


Figure A-3: 2002 WCP South Wall Rehab (New cap details for Crib 6 showing 1' overlay. PS type SSP wall not part of westernmost 9' of crib 6)

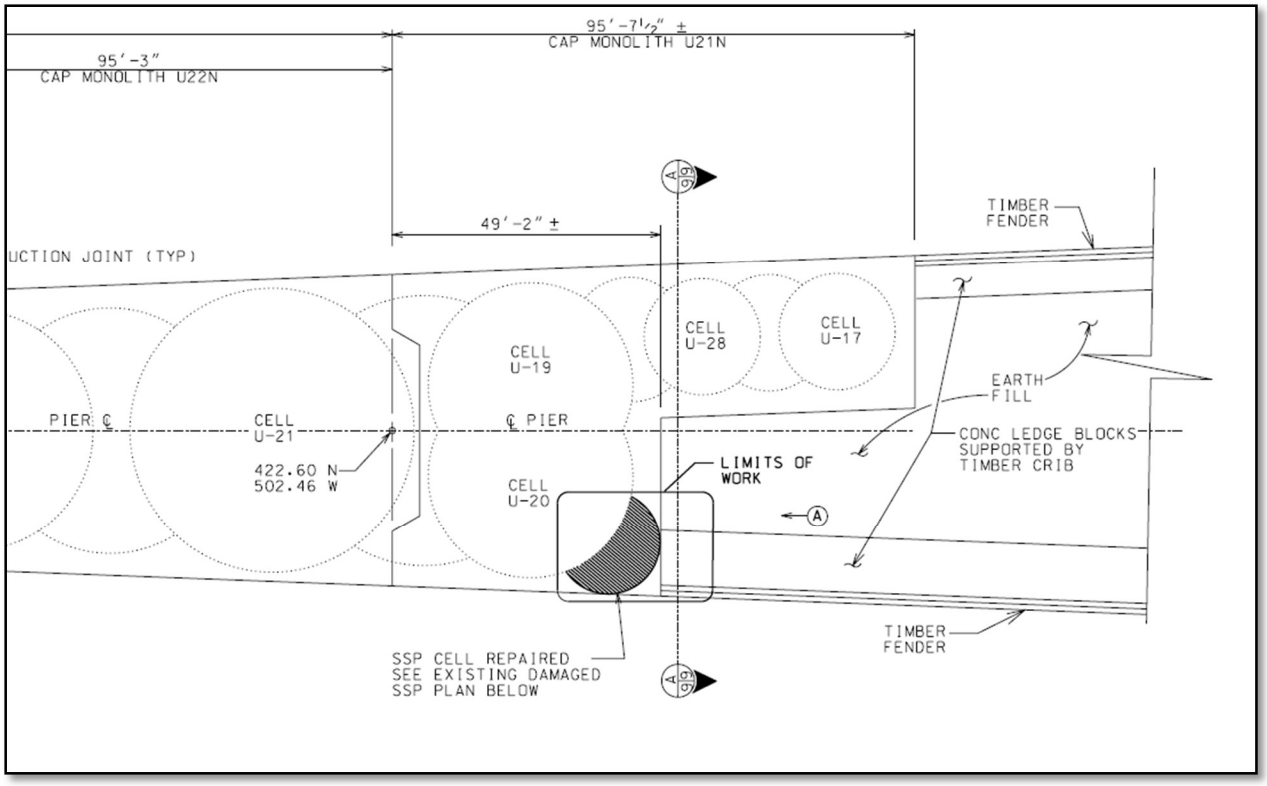


Figure A-4: 1994 Repair Drawings - Overall Plan (2020 Strike Location)

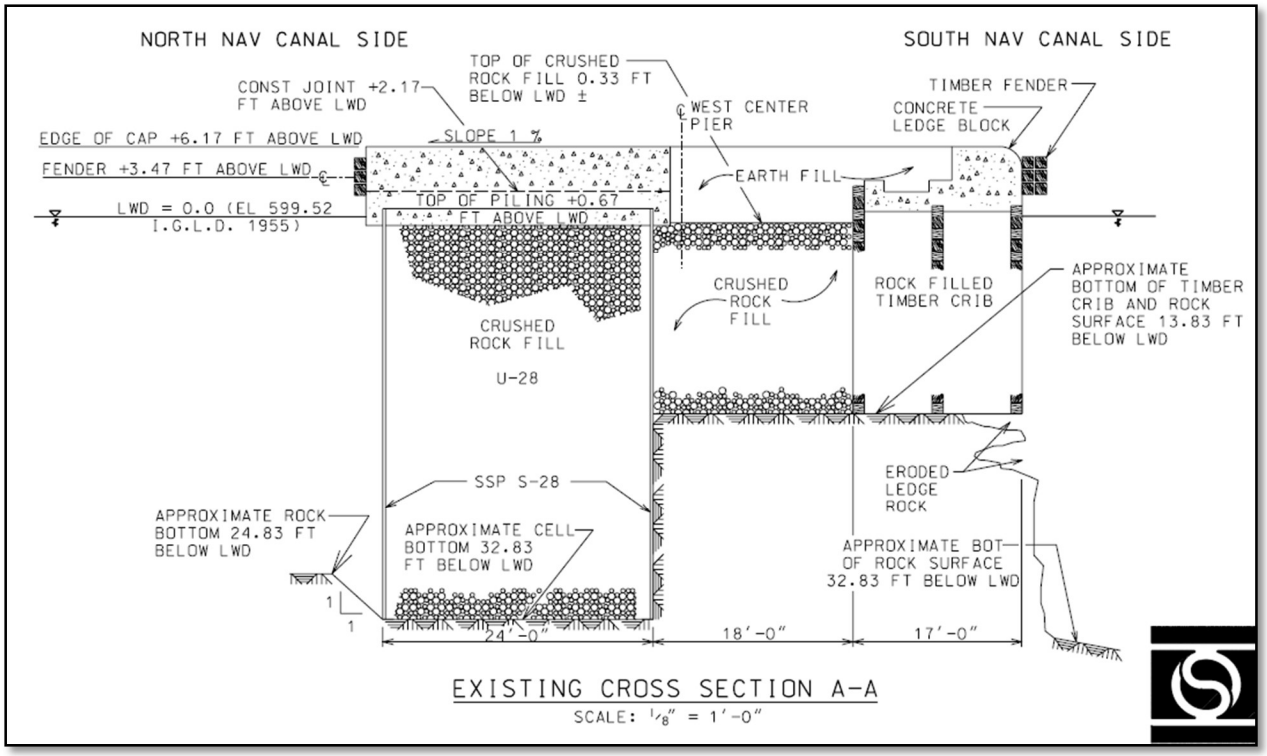


Figure A-5: 1994 Repair Drawings – Cross Section (2020 Strike Location)

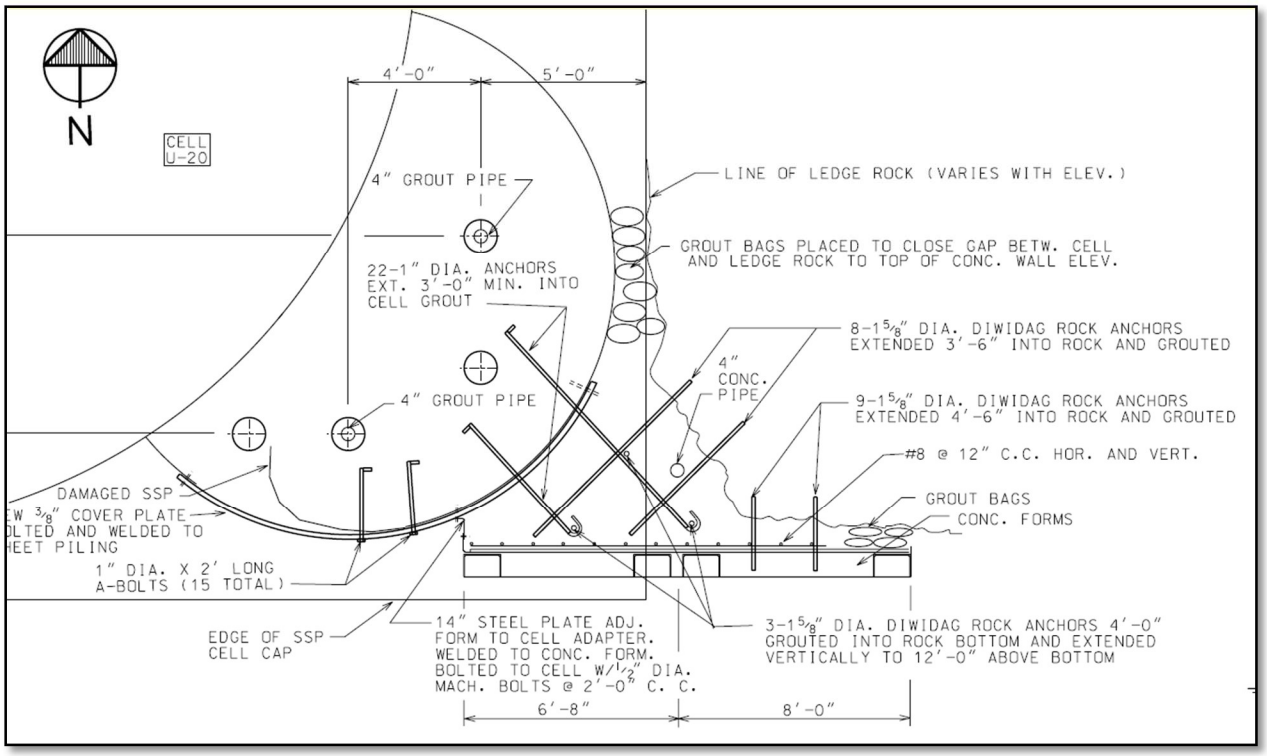


Figure A-6: 1994 Repair Drawings - Plans (Cell West of 2020 Strike Location and rock ledge below crib #6)

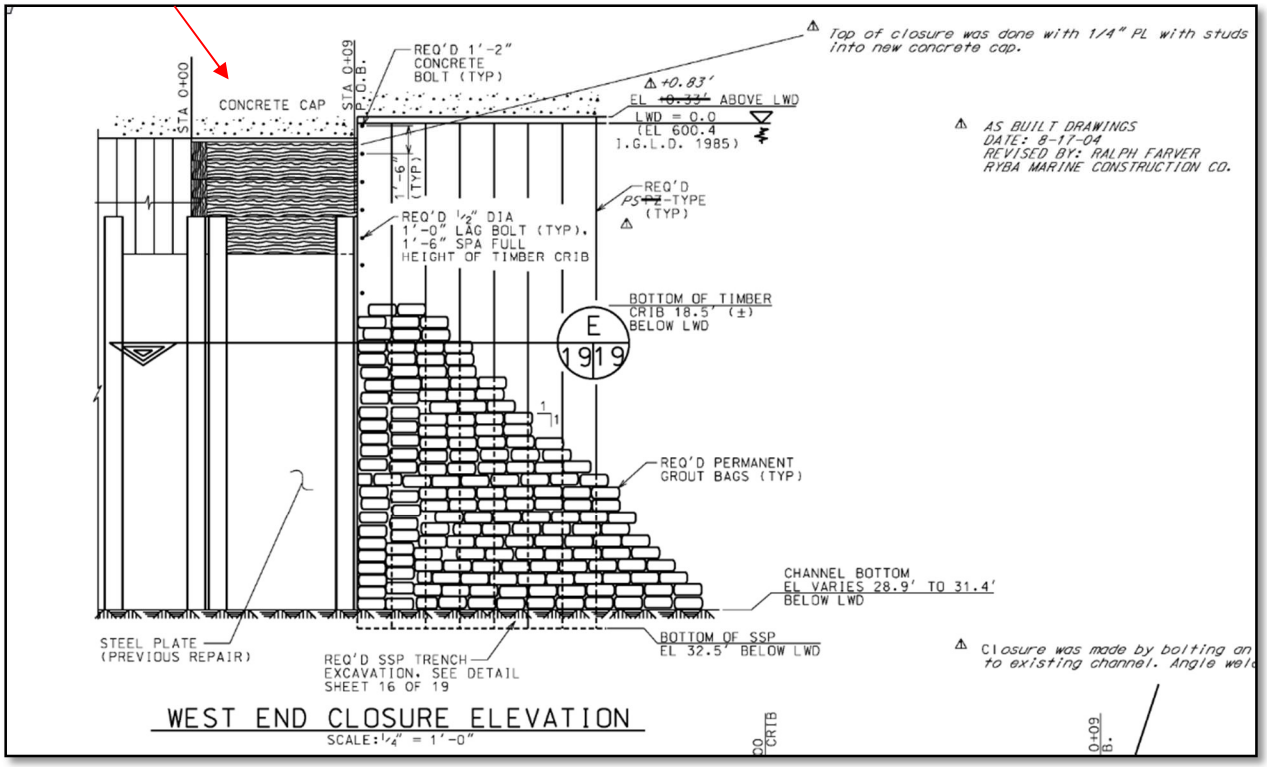


Figure A-7: 1994 Repair Drawings – Elevation (2020 Strike Location)

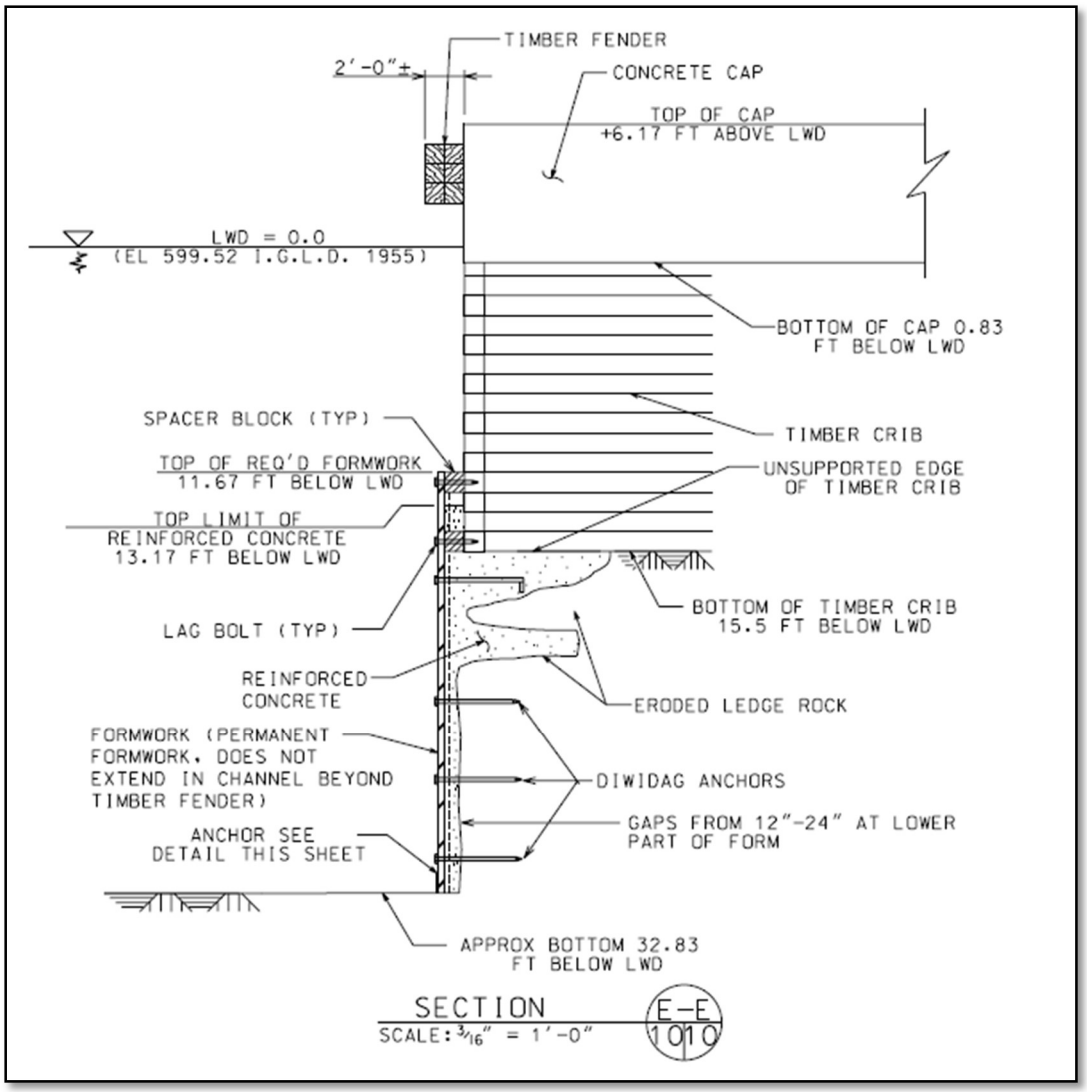


Figure A-8: 1994 Repair Drawings – Section Through Crib (2020 Strike Location)

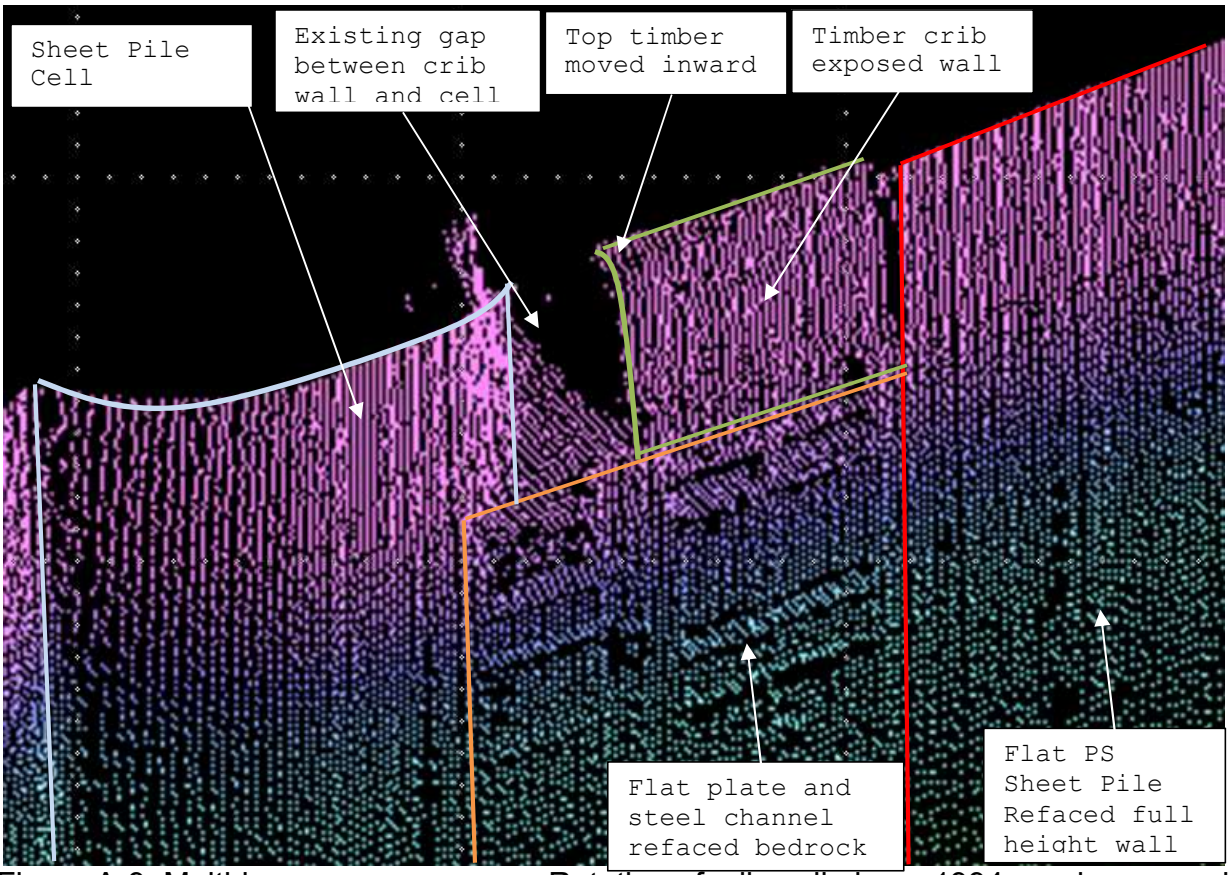


Figure A-9: Multi-beam sonar survey – Rotation of crib wall above 1994 repair area and rolled top crib visible

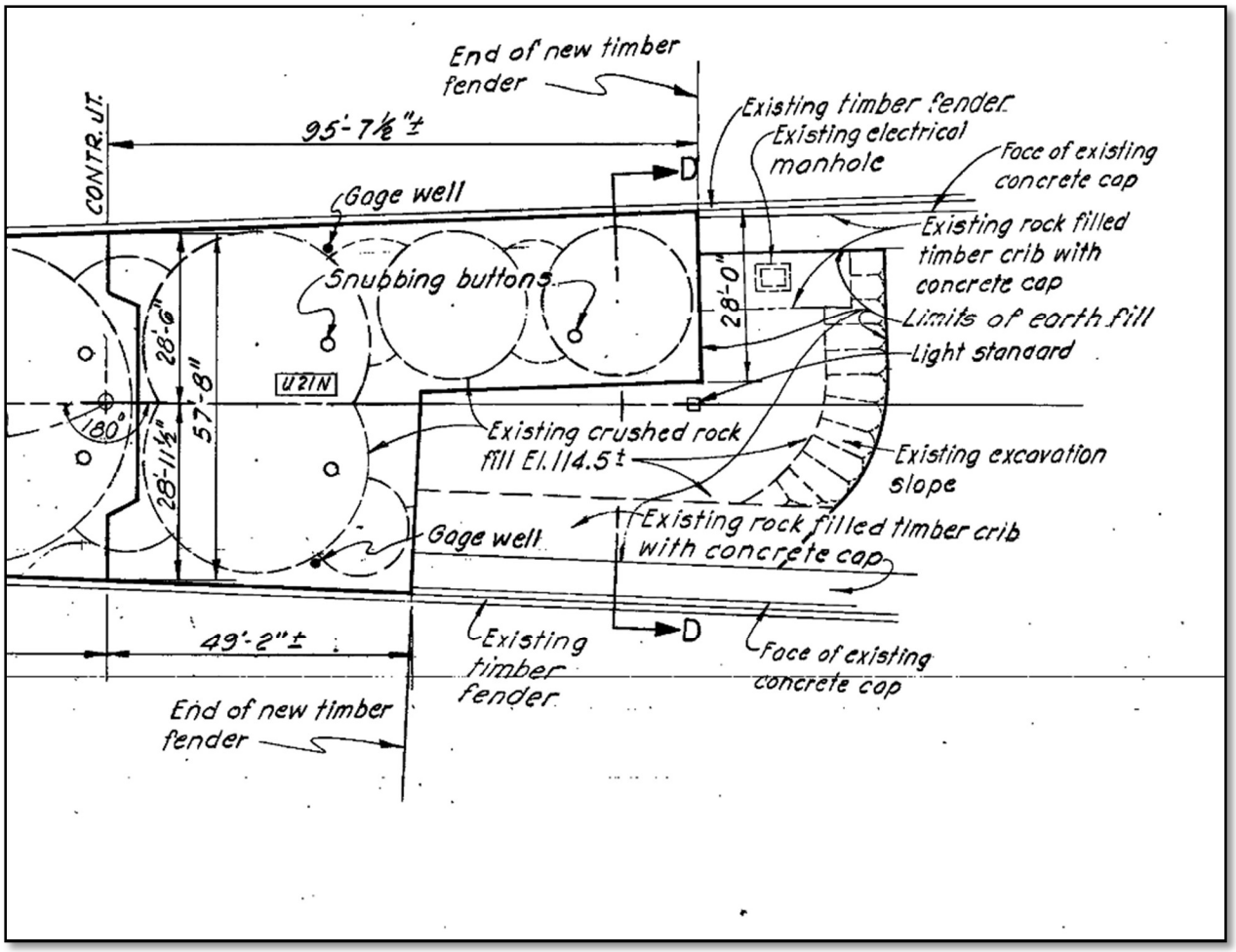


Figure A-10: 1964 WCP Extension Drawings - Plan

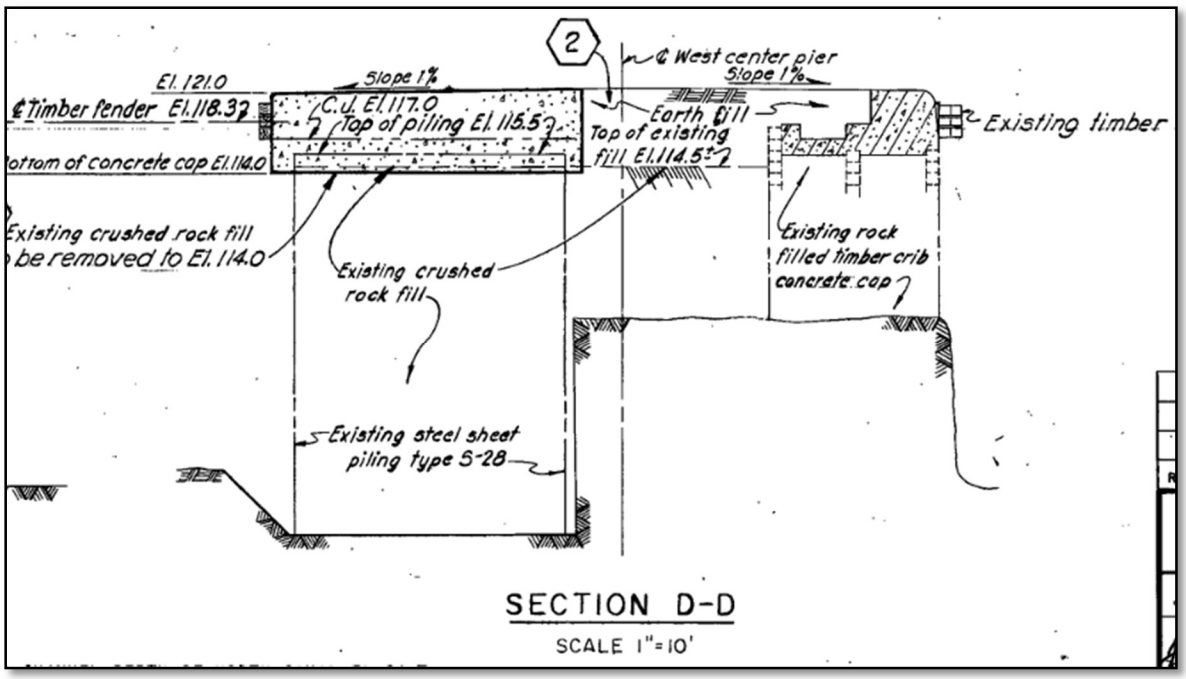


Figure A-11: 1964 WCP Extension Drawings – Section D-D

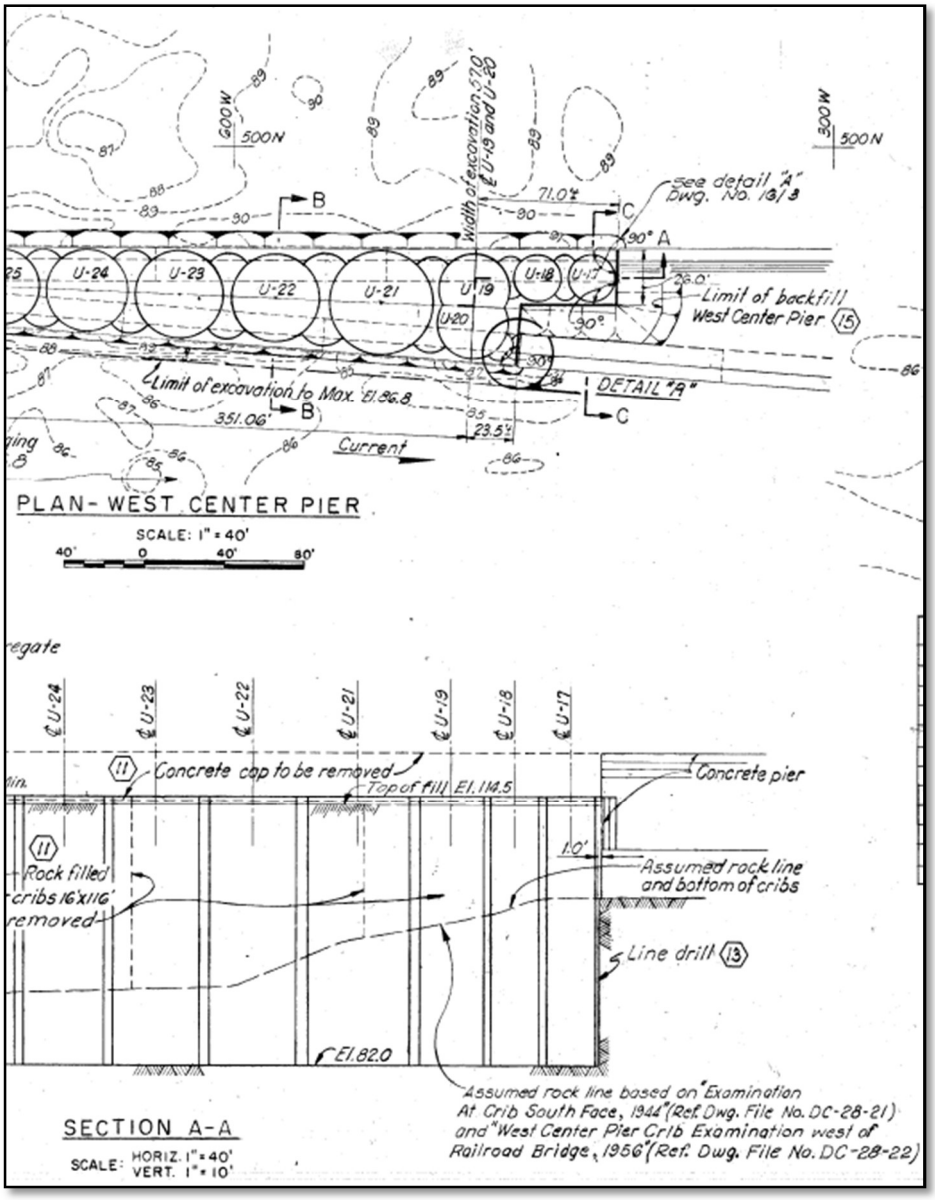


Figure A-12: 1964 WCP Extension Drawings – Demo Plan & Elevation

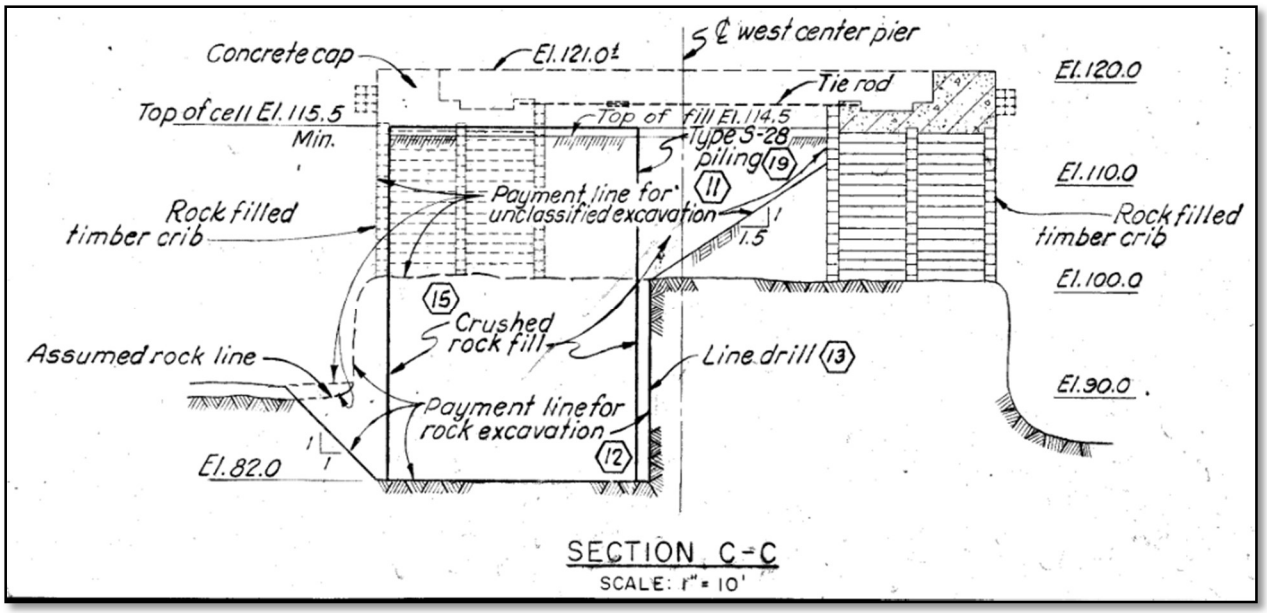


Figure A-13: 1964 WCP Extension Drawings – Demo Section C-C

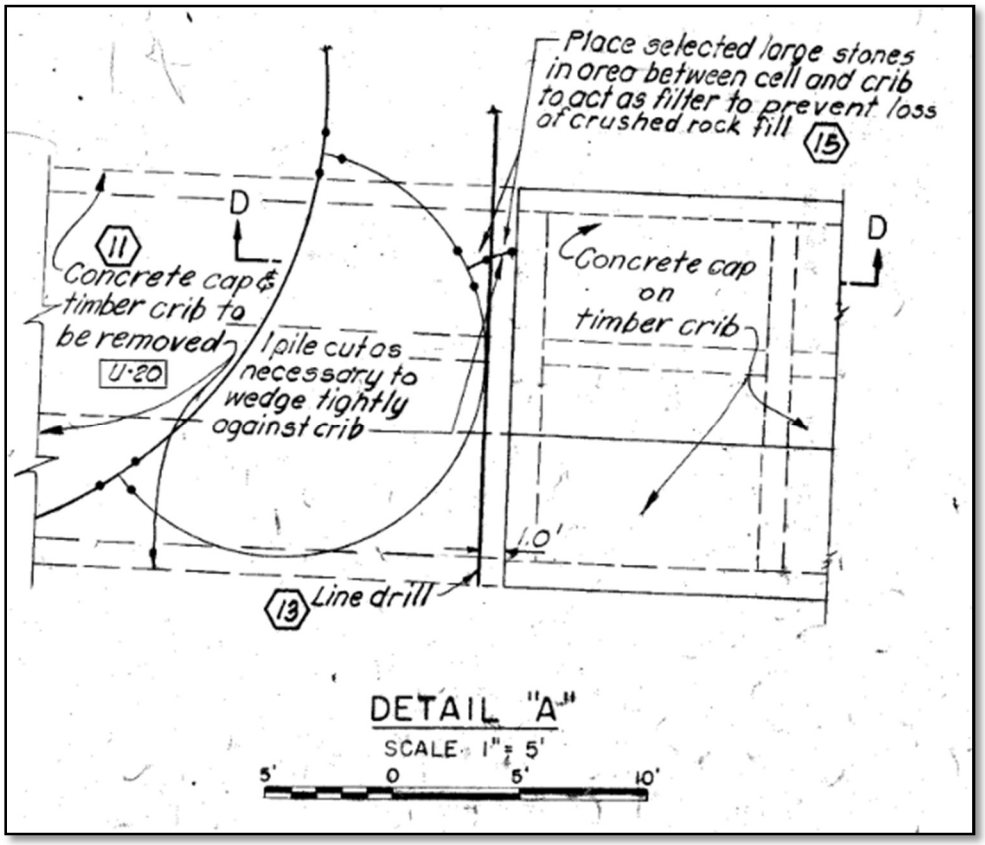


Figure A-14: 1964 WCP Extension Drawings – Detail A

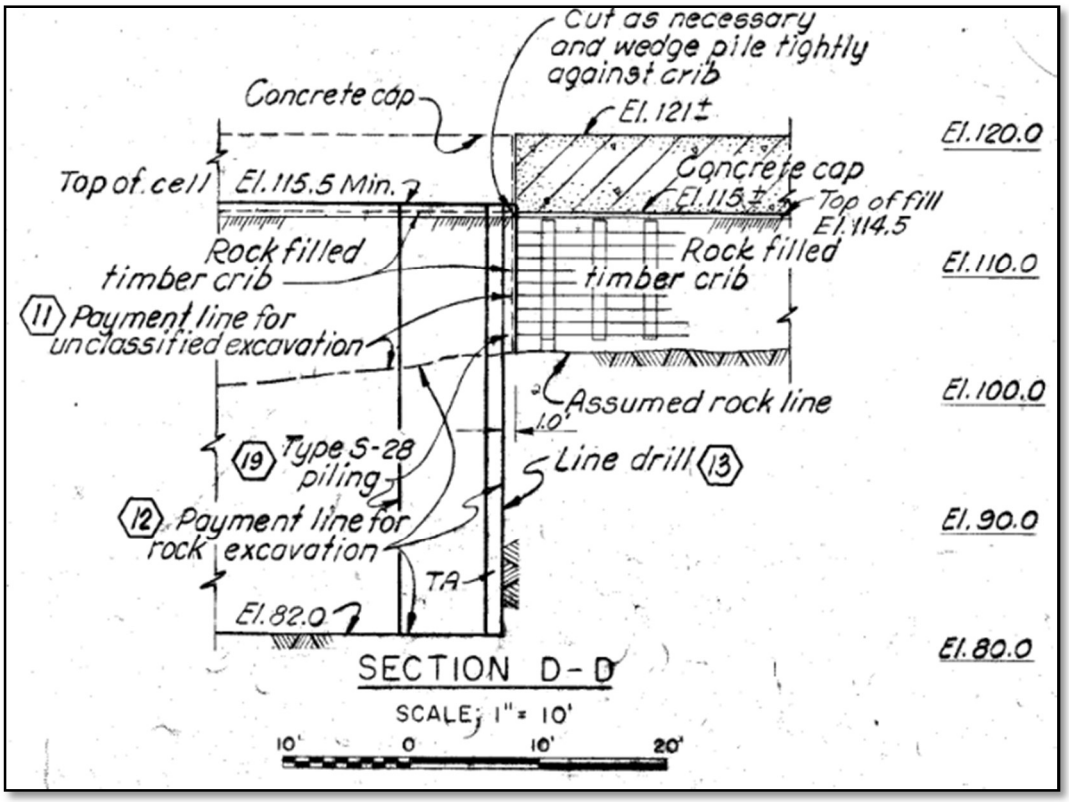


Figure A-15: 1964 WCP Extension Drawings – Detail A, Section D-D

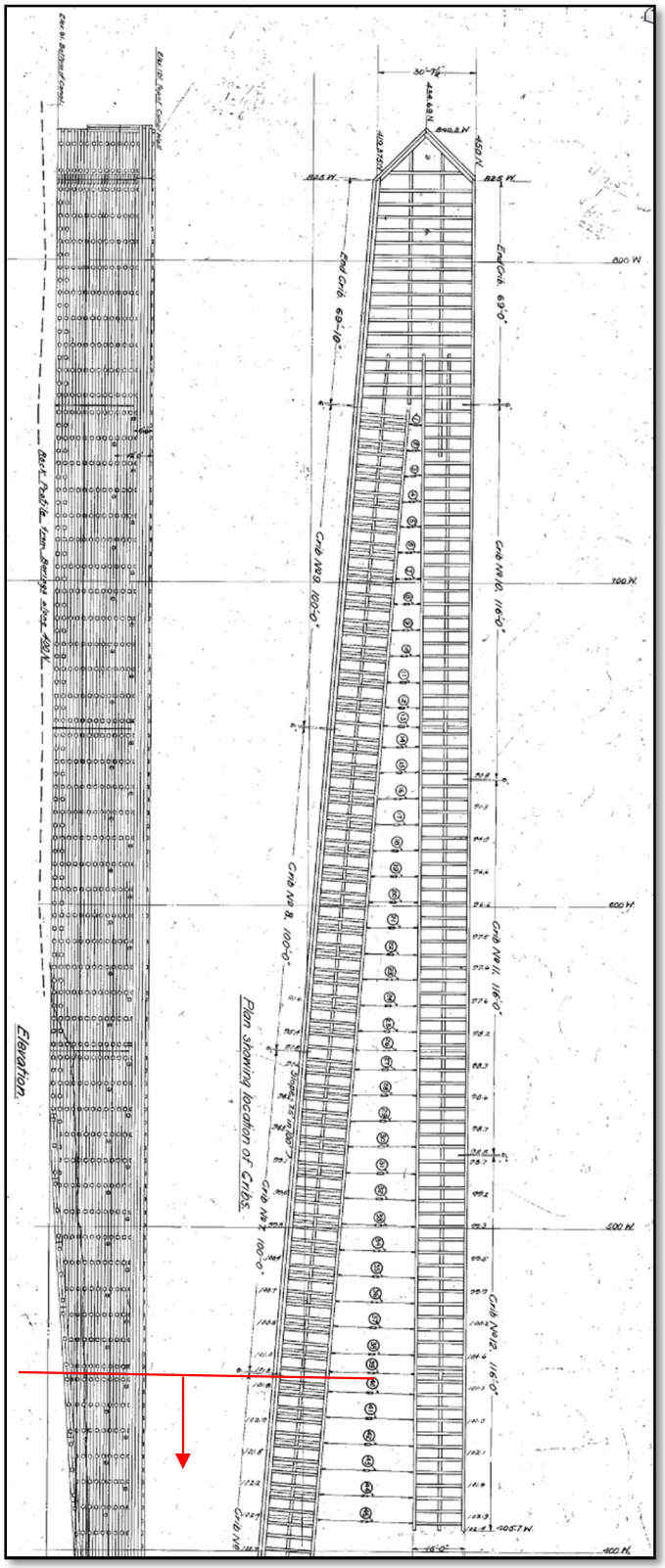


Figure A-16: 1906 WCP Crib Drawings – Plan (start of crib #6 designated by red line & arrow)

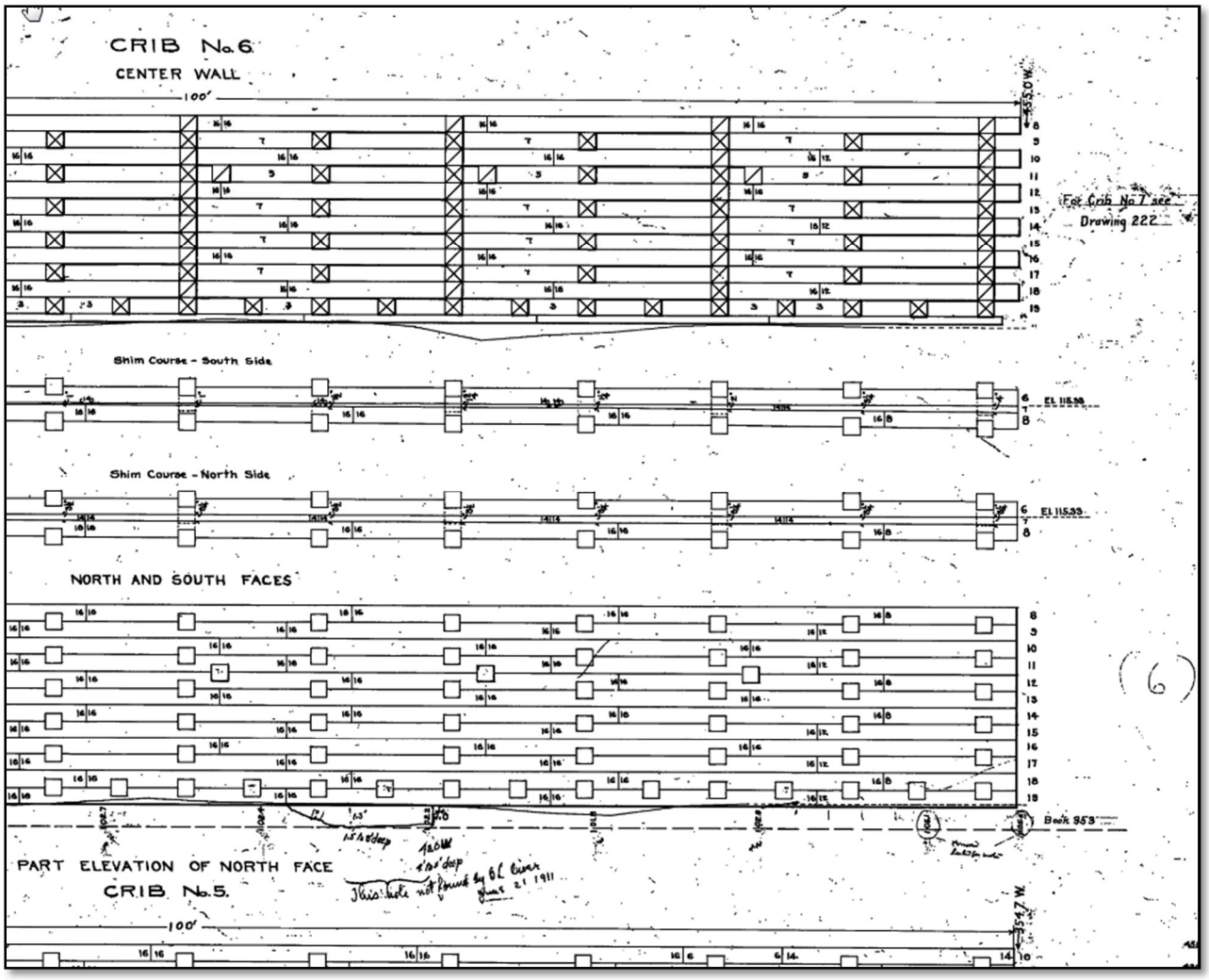


Figure A-17: 1906 WCP Crib Drawings – Crib 6 Detail

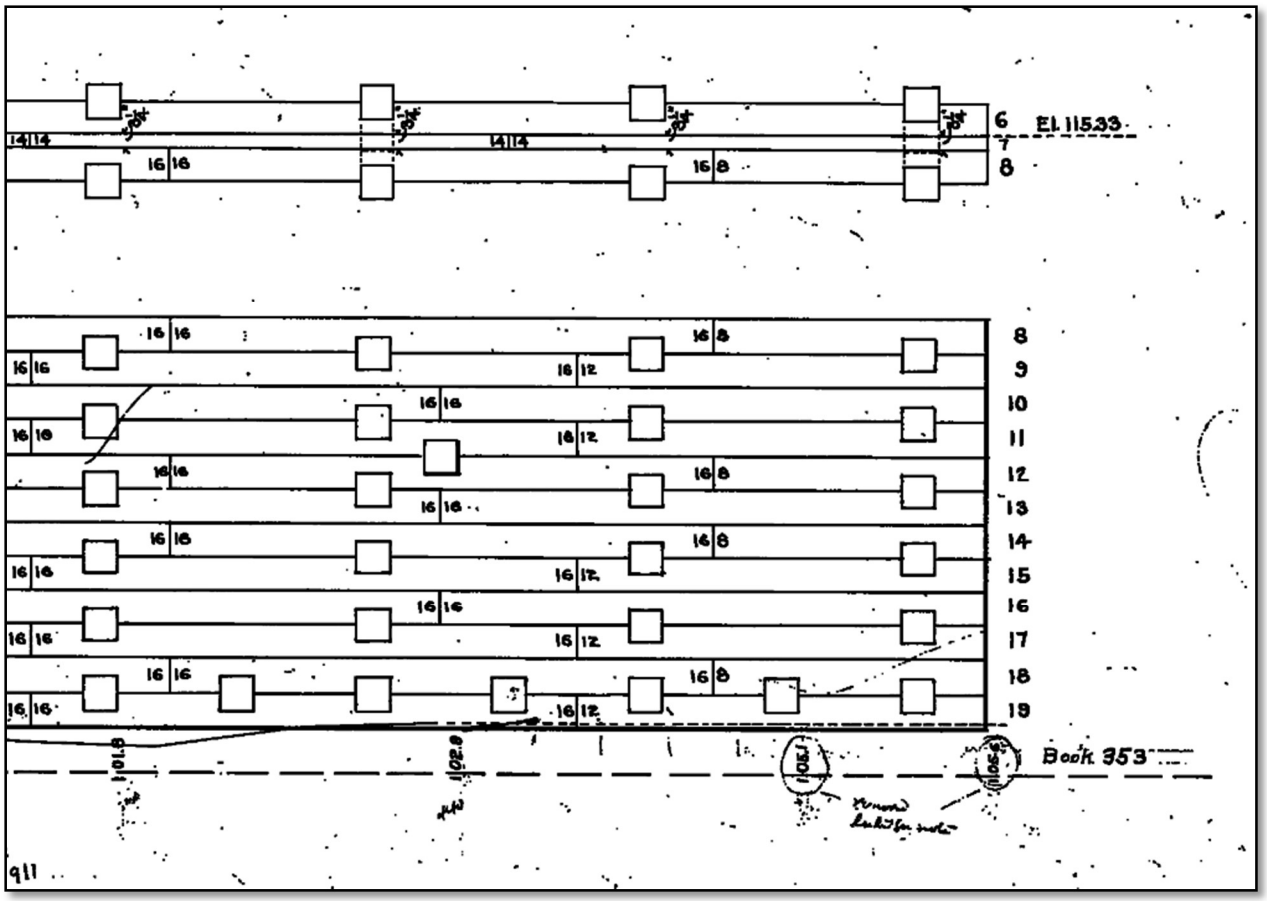


Figure A-18: 1906 WCP Crib Drawings – Crib 6 Detail (2020 Strike Location)

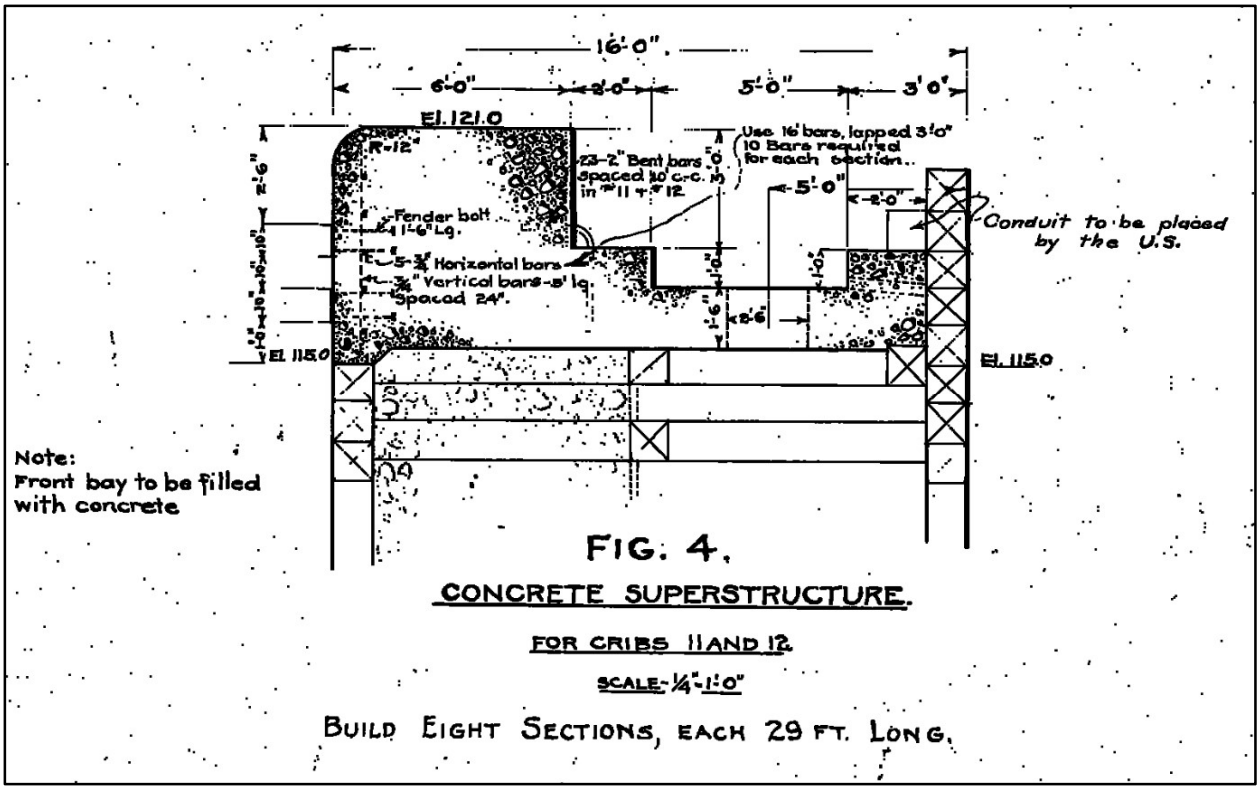


Figure A-19: 1906 WCP Crib Drawings (Cribs 11 & 12 Typical Section believed to be similar at crib 6)